PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Apparatus for Hot-sheathing Electric Cables with Tubular Metal Sheaths

We, PIRELLI SOCIETA PER AZIONI, a company incorporated under the laws of Italy, of Centro Pirelli, Piazza Duca d'Aosta 3, Milan, Italy, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to the extrusion of metal sheaths on electric cables, with particular regard to aluminium sheaths. As is known, in the conventional processes for extruding metal sheaths on electric cables by a ram-type press, the metal is extruded in the solid state and therefore it is necessary to employ very high values of the specific pressure exerted on the metal to impart to it the plastic deformation necessary to secure extrusion. These specific pressures may reach values of thousands of times that of the atmosphere.

The chief object the of present invention is that of operating on the metal as much as possible in the molten state so as to reduce the specific pressures to considerably lower values, of the order, for instance, of from tens to hundreds of atmospheres, thus reducing the phase of plastic deformation of the metal in the solid state to the indispensable minimum.

In order to impart the necessary pressure to the metal in the liquid state, it is not easy to resort to the usual means, such as the use of rams or the like, first because problems of fluid-tightness where molten metals are concerned require a complicated solution, and secondly since there are other serious problems concerned with the metals used in the construction both of the ram and of the cylinder. In particular, in the case of aluminium, there are practically no steels which are not rapidly corroded by molten aluminium. Moreover the use of rams to transmit pressure is unsuitable for the continuity of the process, unless valve systems are adopted which permit the process to be carried out with a number of cylinders and rams. In any case these methods are very complicated and uncertain in their results.

According to the present invention the use of rams is eliminated and replaced by employing compressed gas, which permits the solution of the problems of fluid-tightness and resistance to corrosion of the elements intended to come in contact with molten metal in a considerably simpler way, as will be described below.

In using gas pressure in lieu of a ram, it is necessary to employ gas insoluble in the molten metal to be extruded; in particular, for aluminium, it is very advisable to use argon, which, besides being insoluble in molten aluminium, conveniently protects it from oxidation.

The present invention consists therefore in apparatus for hot-sheathing electric cables with a tubular metal sheath, of the type comprising an extrusion press fed with molten metal, wherein the pressure required for extrusion is supplied by means of compressed gas, insoluble in the molten metal, fed at the upper end of a substantially vertical press cylinder and that the said cylinder is provided with heating means located immediately upstream of an extrusion head, which is made of a material, at least on its external surface, resistant to the corrosion of the molten metal and is provided with heating and cooling means, the heating means serving to maintain the metal in the molten state at least up to an extrusion nozzle formed in the head and the cooling means bringing the metal to the pasty state in proximity to the point of extrusion.

In other words, the invention aims at reducing the work of plastic deformation to the minimum possible by placing the heating and cooling means of the nozzle in such a

[Pr]

position as to produce solidification of the metal in the extrusion nozzle but a little before it emerges from the orifice of the said nozzle. If the nozzle comprises only a frusto-conical portion opening at its narrower end directly on to the cable being sheathed, the work of plastic deformation can be considerably reduced but not completely eliminated, as the solidification of the metal preferably takes place only in the downstream portion of the nozzle with respect to the direction of extrusion. The work of plastic deformation may be practically eliminated by using a nozzle in which the frusto-conical portion terminates in a cylindrical length of uniform diameter; the solidification of the metal takes place in that case when it assumes a cylindrical shape having dimensions nearly equal to those of the extruded sheath, so that all that is then required is the simple operation of drawing the sheath, if desired slightly reducing its diameter. The sheathed cable is drawn through a die and/or a rolling mill in order to reduce the diameter of the sheath and/or to stretch it longitudinally so as to impart to it, besides the required size, the necessary flexibility and elasticity.

Although the above-indicated features of the present invention permit elimination of many of the present drawbacks of this technique, they are not sufficient completely to overcome the main inconvenience, that is discontinuity of the extrusion operation. This discontinuity is practically due to two main factors, namely, the necessity of supplying the press with molten metal as sucessive charges in the cylinder are nearly exhausted and frequent interruptions, owing to the replacement of parts in consequence of wear, especially when the molten metal is aluminium, if said parts are constructed according to current practice employing extrusion apparatus of the ram type.

By the use, in order to effect extrusion, of high-pressure gas in place of a ram, difficulty arising from the second of the above factors is overcome by reason of the fact that surfaces with which the molten metal comes into contact can be made of material not subject to corrosion thereby. To meet the first factor, a system for the controlled supply of molten metal from a furnace to the press cylinder via a reserve container has been devised and forms the subject matter of co-pending Patent Application No. 6921/62 (Serial No. 910,048) divided out from the present application.

For the purpose of employing non-corrodible materials, the cylinder of the press comprises a pressure-resistant outer casing (which may be made of a suitable type of steel), a refractory crucible within the said casing, made of a material chemically neutral with respect to the molten metal, e.g. aluminium, and not liable to corrosion by the latter and a porous, or at least gas-permeable layer, interposed between the crucible and the casing, this porous layer being subjected to the gas pressure existing in the cylinder so that the gas, penerating into the porous material, may balance, at least approximately, the pressures acting on the outer and inner surfaces of the crucible. Under these conditions the crucible serves only as a container for the molten metal without being charged with an internal pressure of some tens or hundreds of atmospheres, which is required to extrude the metal. Heating elements to maintain the metal to be extruded may be located in the above porous layer.

Further characteristics and advantages of the present invention will appear from the following description, made with reference to the accompanying drawing illustrating by way of example apparatus in accordance therewith, and in which:—

Figure 1 illustrates diagrammatically in vertical section an extrusion press in accordance with the invention, and

Figure 2 illustrates an alternative form of the extrusion nozzle used in a press as in Figure 1.

Referring to Figure 1, the numeral 1 indicates a vertical cylindrical steel casing, resistant to internal pressure, within which a refractory crucible 2 is coaxially disposed. The casing 1 is closed in a fluid-tight manner by a lid 3 and as shown, the upper edge 2[1] of the crucible 2 is spaced from the lid 3. Between the crucible 2 and the casing 1 there is a layer of porous material 5, to which the atmosphere existing in the crucible 2 has access by virtue of its spacing from the lid 3. The crucible 2 is preferably made of graphite which, as known, is not corroded by molten metals. The porous layer 5 may be constituted by any refractory insulating material permeable to gases, as, for instance, a refractory material ground into granules.

All the above-described components form the press cylinder to which the molten aluminium 6 is fed through a steel tubular connection 17, situated in proximity to the upper end of the cylinder and internally lined with a tube 16 resistant to the corrosive action of the molten metal, made, for instance, of graphite. A thermometric element 18 extends through the lid 3 and dips into the molten metal 6. The layer 5 contains heating resistors 4 supplied with electric current controlled by the thermometric element 18 through a known form of thermo-regulating appliance, not illustrated in the drawing, in order to maintain the metal 6 constantly in the molten state.

At the bottom of the casing 1 there is fixed, in a fluid-tight manner, an extrusion head 7 of a type generally known for sheathing cables by extrusion, into which extends from the bottom of the crucible 2, a tubular projec-

tion 2'' designed to feed the head with the molten metal 6. As appears from the figure, the projection 2'' is surrounded by a heating resistor 4*a*, and a similar resistor 4*b* surrounds also the neck of the head 7, the resistors 4*a* and 4*b* being controlled in such a way that the metal 6 may enter in the molten state into an annular frusto-conical passage 7*a* in the head 7. This passage becomes narrower in the direction of extrusion F and constitutes a nozzle opening directly on to the cable 8 to be sheathed.

The passage 7*a* is cooled from outside and from inside by means of jackets 7*b*, 7*c*, fed with a cooling fluid through ducts 9 and 10 for the former and through similar ducts, not shown in the figure, for the latter.

In this way solidification of the metal takes place near the outlet of the annular passage 7*a*, whilst in proximity to the inlet it is still in the liquid state, although very near to the solidification point, so that it is important to protect the inner surface of that passage from the corrosive action of the metal. For this purpose the head 7 may be made entirely of metal not liable to corrosion by the molten metal, for instance, titanium, but it may be advisable to make it of steel or other metal and to line the passage 7*a* either with a non-corrodible metal or with a suitable corrosion-resistant enamel, for instance, chromium boride or aluminium oxide or other like material which may be applied by spraying or other method.

The cylinder of the press is provided with maximum- and minimum-level detectors, 15, 14, which function when the molten metal 6 reaches the respective levels, so that the supply of molten metal may be stopped or fed to the press through the connection 16, 17.

The lid 3 is fitted with a pipe 19, controlled by a valve 19*a*, for admitting compressed gas, for instance argon, into the cylinder. The pipe 19 is moreover provided with an exhaust valve 20, through which the gas may be discharged from the press and, if desired, recovered.

Supposing that the press is in the above-described condition and that the connection 16, 17 is closed in a fluid-tight manner by means of a suitable valve, the valve 20 is closed and the valve 19*a* is opened so as to feed compressed gas to the cylinder of the press. At the same time the cable 8 is advanced through the head 7 in the direction of the arrow F and the heating and cooling means 4, 4*a*, 4*b*, 7*b*, 7*c* are adjusted in such a way as to cause the solidification to the pasty stage of the metal 6 only within the downstream portion of the passage 7*a*, this portion being indicated at A. The work of extrusion is therefore substantially reduced to the extrusion of the solid metal, still easily deformable by virtue of its high temperature, existing in proximity to the extrusion point. The tubular metallic sheath 21 so produced on the cable 8 is rapidly cooled at its exit from the extrusion nozzle by means of water jets 11. In consequence of the limited degree of plastic deformation suffered by the solid metal in the extrusion head 7, the resulting sheath 21 will be nearly always less flexible and elastic than is desired. Consequently it will be advisable to impart to the sheath the necessary mechanical properties by subjecting it to a degree of cold-working, such as by drawing the whole through a die 12 and/or a rolling mill 13.

When the stock of molten metal 6 in the press falls to the level of the detector 14, the valve 19*a* situated in the duct 19 is closed and the exhaust valve 20 is opened; then a new amount of molten metal is supplied through the connection 16, 17 up to the maximum level, indicated by the detector 15, and the above-described cycle is repeated. In this mode of operation the extrusion process is discontinuous.

Alternatively, the supply of the molten metal could be carried out without releasing the press from the extrusion pressure, namely, without closing the valve 19*a* and opening the valve 20. This continuous process may be carried out by apparatus as disclosed in the above-mentioned co-pending patent application.

The extrusion head illustrated in Figure 2 has the object of substantially reducing the extrusion pressure by eliminating the work of plastic deformation of the solid metal. For this purpose the extrusion nozzle 7*a* is made of a material which, at least on its internal surface, is resistant to the corrosive action of the molten metal and comprises a convergent portion B and a cylindrical portion C of constant diameter. The portion B is provided with additional heating resistors 4*c* and 4*d*, while the cooling interspaces 7*b* and 7*c* extend practically only along the length of portion C. The portion B is therefore traversed by the metal still in the molten state, solidification occurring only in the portion C of constant diameter. Owing to the existence of the cooling interspace 7*c* between the cable 8 and the metal flowing through portion C, the resulting sheath 21' has an inner diameter somewhat greater than the outer diameter of the cable. Moreover, on account of the practically negligible degree of plastic deformation, the sheath 21' is relatively brittle. In this case it is therefore necessary to resort to a subsequent cold mechanical working of the sheath by means of reduction units, analogous to those indicated at 12 and 13 in Figure 1, which stretch the sheath 21' and reduce its diameter so as to bring it into contact with the cable 8.

The heating elements 4 and 4*a* of the press are controlled by the thermometric element

18 in a well-known manner through a regulator not shown in order to maintain the metal always in the molten state. Also the connection 17 may be provided with heating elements for the same purpose.

A thermal control system will be similarly provided for the extrusion head 7, in order to adjust both the heating elements 4*b*, 4*c*, 4*d* and the cooling elements 7*b*, 7*c*, disposed therein so as to ensure the solidification of the metal in the desired zone.

WHAT WE CLAIM IS:—

1. Apparatus for hot-sheathing electric cables with a tubular metal sheath, of the type comprising an extrusion press supplied with molten metal, characterised by the fact that the pressure required for extrusion is supplied by means of compressed gas insoluble in the molten metal, fed at the upper end of a substantially vertical press cylinder and that the said cylinder is provided with heating means located immediately upstream of an extrusion head, which is made of a material at least on its internal surface resistant to corrosion by the molten metal and is provided with heating and cooling means, the heating means serving to maintain the metal in the molten state at least up to an extrusion nozzle formed in the head and the cooling means bringing the metal to the pasty state in proximity to the point of extrusion.

2. Apparatus according to Claim 1, characterised by the fact that the press cylinder comprises an outer casing resistant to internal pressure, a refractory crucible within the said casing and a porous layer interposed between the crucible and the casing, the said porous layer being subjected to the pressure of the gas in the cylinder so as approximately to balance the pressures acting on the outer and inner surfaces of the crucible.

3. Apparatus according to Claim 1, in which the extrusion nozzle comprises an annular frusto-conical passage, the heating means being located in proximity to the wider portion of the passage and the cooling means in proximity to its narrower portion.

4. Apparatus according to Claim 1, in which the extrusion nozzle comprises a convergent portion followed, in the direction of movement of the cable, by a cylindrical portion, characterised by the fact that the convergent portion is provided with the heating means to prevent the solidification of the metals in said portion, while the cylindrical portion is provided with the cooling means to ensure the solidification of the metal in this portion.

5. Apparatus according to Claim 1, characterised by the fact that the extrusion head is provided with a thermo-regulating system whereby both the heating means and the cooling means disposed therein are controlled.

6. Apparatus according to Claim 1, characterised by the fact that the extrusion nozzle is made entirely of a metal, for instance, titanium, not liable to corrosion by the molten metal.

7. Apparatus according to Claim 1, characterised by the fact that the extrusion nozzle is made of steel or other metal having, on its internal surface, a lining of a metal, for instance, titanium, not liable to corrosion by the molten metal.

8. Apparatus according to Claim 1, characterised by the fact that the extrusion nozzle is made of steel or other metal having, on its internal surface, a lining of an enamel not liable to corrosion by the molten metal, for instance, chromium boride or aluminium oxide.

9. Apparatus for hot-sheathing electric cables substantially as herein described with reference to Figure 1 of Figure 1 as modified by Figure 2 of the accompanying drawing.

10. An electric cable having a sheath applied by apparatus as in any one of the preceding claims.

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910047 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

FIG.1

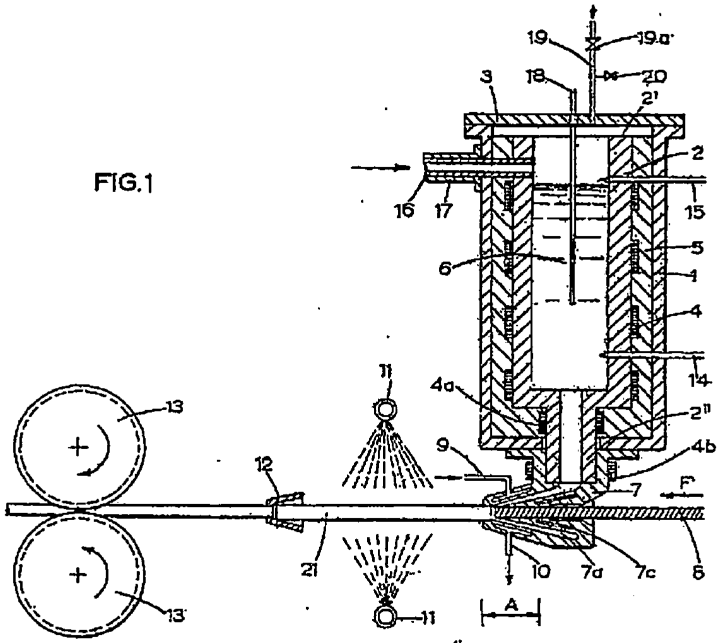

FIG.2